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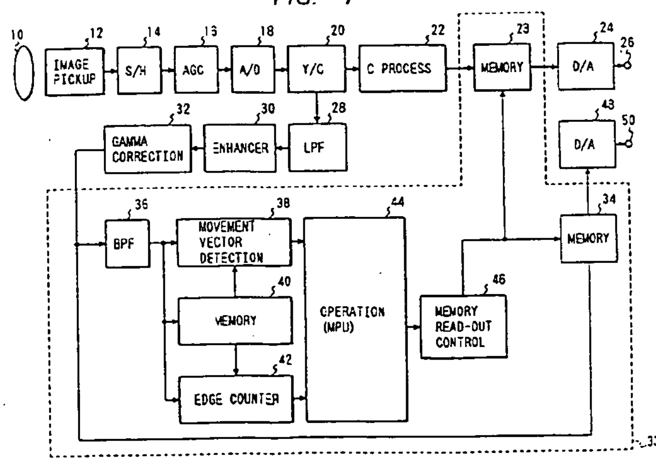
(54) Movement vector detecting device

(57) There is disclosed a movement vector detecting device provided with a movement vector detecting circuit for detecting a movement vector in each of blocks obtained by dividing an image frame, a detecting circuit for detecting the number of inversions with respect to a predetermined threshold value in each of the blocks, and operation means for varying the weighting of the movement vector value detected by said movement vector detecting means for each block, based on the output of said detecting means for each block, based on the output of said detection means, and effecting a predetermined averaging operation, thereby calculating a movement vector for the entire image frame.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a movement vector detecting device, and more particularly to a device for detecting a movement vector from an image signal.

Related Background Art

The movement vector detecting device has been employed in the image encoding device or the image vibration compensating device. For movement vector detection by image signal processing, there have been known a time-space inclination method disclosed for example in the U.S. Patent No. 3,890,462 and in the Japanese Patent Publication No. 60-46878, a correlation method based on calculation of correlation, and a block matching method.

In the time-space inclination method, the amount of movement is calculated from the difference d in luminance between frames (or fields) and the difference Δ between pixels in a frame. There is utilized a property that the image signal of a moving image is an average in time with a field cycle time, and that the edge becomes less sharp and the difference Δ in luminance among pixels becomes smaller as the amount of movement of image becomes larger. The amount of movement is defined by d/Δ, namely the difference d in luminance among frames or fields, normalized by the difference Δ in luminance among pixels. The details of the time-space inclination method are described by B. K. P. Horn et al., Artificial Intelligence 17, p.185 - 203 (1981).

The block matching method consists of dividing the input image signal into blocks of a suitable size (for example 8 pixels by 8 lines), comparing each block with the pixels of a predetermined area in a preceding frame (or field) and determining the most resembling position by laterally moving the comparing position within the image frame. For example there is searched a position where the sum, within the block, of absolute difference of pixels between the frames (or fields), and the movement vector is represented by the relative displacement of the most resembling blocks. The details of the block matching calculation are reported by M. Ogami et al., Information Processing, Vol. 17, No. 7, p.634 - 640 July, 1976.

In these methods, however, it has been difficult to exactly detect the movement vector, or the detected movement vector has not been reliable, in case the unit block for movement vector detection contains only low spatial frequencies and lacks characteristic pattern (such as sky, water surface, white wall or asphalt surface), or in case said unit block contains a plurality of similar characteristic points with a high spatial frequency (such as flower field, leaves of a tree or a door with grid pattern), or in case an object having the edge only in a specified direction (such as an oblong rod) moves along the direction of said edge.

If a high-efficiency image encoding device or an image vibration compensating device is operated according to an erroneous movement vector or a movement vector involving a large error, the precision of encoding or compensation is significantly deteriorated, and the image quality may become even worse by such encoding or compensation.

In the field of vibration detection and vibration compensation utilising the movement vector, the present applicant already has the following granted US patents: U.S. Patents Nos. 5,198,896, 5,189,513, 5,296,925, 4,965,892, 5,012,270 and 5,107,293.

The present invention is to resolve the above-mentioned drawbacks of the prior art, and is concerned with providing a movement vector detecting device capable of accurately detecting the movement regardless of the state of the image.

The present invention is also concerned with providing a vibration compensating device capable of accurately detecting the movement vector of an object image regardless of the pattern thereof, and enabling the realisation of optimum movement compensating characteristics without erroneous operations.

The present invention is additionally concerned with providing a camera constantly capable of accurate compensation for vibration regardless of the state of the object to be photographed.

In accordance with the present invention there is provided an image pick-up device as set out in claim 1.

Still other features of the present invention will become fully apparent from the following description to be taken in conjunction with the attached drawings, which are given by way of example.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of an embodiment of the present invention;
Fig. 2 is a view showing the relation between the spatial frequency and binary patterns;
Figs. 3A and 3B are views for explaining binary patterns;
Fig. 4 is a chart showing an example of the evaluation function;
Figs. 5A to 5C are charts showing the principle of edge detection by the zero crossing method; and
Fig. 6 is a view showing a binary pattern having edges periodically on a vertical line.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now the present invention will be clarified in detail by an embodiment thereof shown in the attached drawings.

Fig. 1 is a block diagram of a video camera with an antivibration devices, constituting an embodiment of the

present invention. In this embodiment, the vibration of image is suppressed by storing the phototaken image signal of an image frame in an image memory, and controlling the read-out range from said image memory according to the detected movement vector.

In Fig. 1, an image pickup device 12 converts an object image, formed by a phototaking lens 10, into an electrical signal. In the present embodiment, the image pickup device 12 releases a line-sequential color difference image signal. The output of said image pickup device 12 is supplied, through a sample hold (S/H) circuit 14, to an AGC (automatic gain control) circuit 16. Which automatically regulates the gain of the output signal of the S/H circuit 14 and of which output is converted into a digital signal by an A/D converting circuit 18.

A Y/C separation circuit 20 is composed of two 1H delay lines and an adder for adding the input and a 2H delayed signal. The output of said adder is supplied to a C process circuit 22 constituting a color signal processing circuit, while a 1H delayed signal is supplied to a low-pass filter (LPF) 28 of a luminance signal processing system. The C process circuit 22 generates a chroma signal from the output of the Y/C separation circuit 20, and its output is temporarily stored in a memory 23 in an image vibration suppressing circuit 33 to be explained later.

In the luminance signal processing system, the LPF 28 eliminates the carrier component of the line-sequential color difference signal, from the signal supplied from the Y/C separation circuit 20. The output of the LPF 28 is supplied to an enhancer 30 for edge enhancement. The enhancer 30 normally adds, to the input signal, a secondary differentiated signal thereof. A gamma correction circuit 32 avoids the saturation in the high-light area and widens the dynamic range, on the output of the enhancer 30. The ordinary luminance signal process is completed in this manner, and the output of the gamma correction circuit is supplied to the image vibration suppressing circuit 33.

In said image vibration suppressing circuit 33, the output of the gamma correction circuit 32 is supplied to a field (or frame) memory 34 and a band-pass filter (BPF) 36 consisting of a spatial frequency filter. A memory 34 temporarily stores the entered luminance signal. The BPF 36 extracts, from the output of the gamma correction circuit 32, spatial frequency components useful for movement vector detection. Thus the low and high spatial frequency components are eliminated from the image signal.

In the present invention, the BPF 36 releases the code bit of the digital output signal of the gamma correction circuit 32. This corresponds to the binarization of the luminance signal, employing the DC level as the threshold value. Thus, the circuits succeeding to the BPF 36 can be composed of 1-bit processing system and can therefore be compactized.

The output of the BPF is supplied to a movement vector detecting circuit 38, a memory 40 serving as 1-field time delay means and an edge counter 42. Said movement vector detecting circuit 38 also receives the signal of the preceding field from the memory 40, and detects the movement vector by the calculation according to the time-space inclination method or by the correlation calculation, based on the current field and the preceding field.

The edge counter 42 counts the number of edges in the horizontal and vertical directions contained in each unit block for movement vector detection in the movement vector detecting circuit 38. More specifically, it detects the inversion of output of the BPF 36, by taking exclusive logic sum between the neighboring pixels.

The movement vector (horizontal and vertical components) detected by the movement vector detecting circuit 38, and the number of edges in each block, detected by the edge counter 42, are supplied to an operation circuit 44 composed of a microcomputer, which evaluates the reliability of the movement vector in each block, by the number of edges in the same block. More specifically, the movement vectors respectively detected in the blocks constituting the detection units for the movement vector are weighted by the number of detected edges, and the movement vector for the entire image frame is detected, as will be explained later in more details.

The operation circuit 44 supplies the calculated movement vector to a memory read-out control circuit 46, which, in response, controls read-out control circuit 46, which, in response, controls the read-out positions of the memories 23, 34 so as to cancel the image movement.

The chroma signal read from the memory 23 is converted into an analog signal by a D/A converter 24, and is released from an output terminal 26. Also the luminance signal read from the memory 34 is converted into an analog signal by a D/A converter 48, and is released from an output terminal 50. In this manner, the image signal with suppressed image vibration is released from said output terminals. 26, 50.

In the following there will be given a detailed explanation on the calculation in the operation circuit 44, namely the evaluation of reliability of the movement vector, with reference to Figs. 2, 3A, 3B and 4. Fig. 2 shows an orthogonal coordinate system representing the spatial frequency area, wherein the abscissa fx indicates the horizontal spatial frequency while the ordinate indicates the vertical spatial frequency. Pattern shown on the coordinate system indicates a binary pattern corresponding to the spatial frequency of the illustrated position. In general, the spatial frequency distribution of an image assumes a cross-shape pattern with limited diagonal components.

In the movement vector in general, the component of movement in a direction orthogonal to the direction of edge (tangential direction) of the image can be detected with satisfactory precision, but the component in the direction of edge is difficult to detect, with low reliability of detected value. Also in the direction orthogonal to the edge, the reliability becomes low if the periodical pattern exists in said direction, because of the possibility of mismatching.

For example, in case of an edge extending in the vertical (y) direction, the x component of the movement vector is detectable, but y component is not detectable. In case of a rough pattern as shown in Fig. 3A, with a block size of 10 x 10 pixels, there are observed 10 edges in the x-direction and 0 edges in the y-direction. In such case, the detected value of y-component of the movement vector is unreliable.

Also in case of a pattern shown in Fig. 3B, with a higher spatial frequency with periodicity in the x-direction, the detected value in the y-direction is unreliable because there is no edge in the y-direction as in the case of Fig. 3A. The reliability becomes also low in the x-direction, because of the possible mismatching resulting from the periodicity. If a block size of 10 x 10 pixels is employed for the pattern of Fig. 3B, there are obtained 90 (= 9 x 10) edges in the x-direction and 0 edge in the y-direction. The detected value in the x-direction is unreliable because of too many edges, and the detected value in the y-direction is also unreliable because of absence of edge.

Fig. 4 shows an example of the weighting function (evaluating function) for the number of detected edges, wherein n indicates the block size in the x- and y-directions. The maximum number of edges in a block of n x n pixels is n(n - 1). When the number of edges is close to zero, the evaluation is low because the effective information for movement vector detection is deficient. On the other hand, the evaluation is also low if the number of edges is very large, because mismatching can happen easily. The operation circuit 44 evaluates the x- and y-components of the detected movement vectors, individually utilizing said weighting function, and effects a process of averaging similar movement vectors with weights in a closed output area and eliminating the movement vectors of low reliability.

In the foregoing embodiment, the edge is judged from a particular spatial frequency component extracted by the two-dimensional BPF 36, but it is naturally possible also to count the edges of boundaries or contours by extracting edge information from multi-value image signal. Direct edge detection from the luminance signal can be achieved by the zero-crossing method, in which the edge is detected by secondary differentiation of the luminance signal, as detailedly reported by D. Marr and E. Hildreth in "Theory of Edge Detection", Proceeding of the Roval Society of London, B207, 1980, pp187 - 217.

Fig. 5A shows an edge part of an image, while Fig. 5B shows a differential of the signal shown in Fig. 5A, and Fig. 5C shows a differential of the signal shown in Fig. 5B, or a second-order differential of the signal shown in Fig. 5A. The wave form of said second-order differential shown in Fig. 5C inverts the sign at the center of the edge, and said sign inverting point is called zero crossing point. Thus the edges can be detected in the horizontal and vertical directions, by effecting second-order differentiation in said directions. The reliability of the detected movement vector can be evaluated also by the edges detected by such zero crossing method.

There have also been proposed other types of edge detectors, which are likewise applicable to the present invention. For example there are already known Roberts' edge detector reported by L. G. Roberts, "machine perception of three-dimensional solids", in Optical and Electro-optical Information Processing, and J. T. Tippett et al. (eds,), MIT Press, Cambridge, Mass., 1965, pp.159 - 197, and Prewitt's edge detector reported by J. M. S. Prewitt, "object enhancement and extraction" in Picture Processing and Psychopictorics; and B. S. Lipkine and A. Rosenfeld (eds.), Academic Press, New York, 1970.

In the foregoing embodiment, the reliability of the movement vector is evaluated by the total sum of the number of edges in the x- or y-direction, but the above-mentioned evaluation function may also be applied to a horizontal or vertical scanning line in each block. The meaning of such method will be explained with reference to Fig. 6.

Fig. 6 shows an example of binary pattern, with a block size of 10 x 10 pixels, and the distributions of the number of edges in the x-and y-direction are shown by histograms illustrated outside of said pattern. The pattern shown in Fig. 6 has edges repeating in the y-direction with a short cycle, so that it is difficult to exactly detect the y-component of the movement vector. However, this pattern has 10 edges in the x-direction and 9 edges in the y-direction, so that the reliability is high in the evaluation by the total sum of the number of edges.

For such pattern, the aforementioned evaluation function may be applied to each horizontal or vertical scanning line. For a block size of n x n pixels, the number of edges present on a horizontal or vertical scanning line is between 0 and (n - 1). Therefore, the evaluation (weight) is made lower in case the number of detected edges is 0 or (n - 1) or close thereto. With this method, the y-component of the movement vector detected in this block is evaluated low.

As will be easily understood from the forgoing description, the reliability of plural detected movement vector values is evaluated by the numbers of edges detected in respective blocks, so that a movement vector of high reliability and high precision can be obtained in the entire image area or in a suitable closed area. Consequently there can be obtained satisfactory performance in the moving image encoding device or in the image vibration compensating device.

Claims

1. An image pickup device comprising:

   image pickup means (12) for effecting photoelectric conversion on an image, formed on an image taking plane of the pickup means to generate an image signal;

   block dividing means (44) for dividing the image taking plane of said image pickup means into plural blocks; and

   movement vector detecting means (38, 40) for detecting a movement vector from said image

signal, for each of said plural blocks, and characterised by

detection means (40) for detecting the number of inversions, with respect to a predetermined threshold value, of the image signal, in each of said plural blocks;

operation means (44) for varying the weighting of the movement vector value detected by said movement vector detecting means for each block, based on the output of said detection means for each block, based on the output of said detection means, and effecting a predetermined averaging operation, thereby calculating a movement vector for the entire image frame; and

compensating means (44, 46, 34) for compensating the movement of the image, according to the movement vector for the entire image frame, calculated by said operation means.

2. A device according to claim 1, wherein said movement vector detecting means includes filter means for extracting frequency components suitable for the detection of said movement vector and eliminating unnecessary low and high frequency components.

3. A device according to claim 2, wherein said filter means is adapted to binary digitize the luminance signal, employing a predetermined DC level as the threshold value.

4. A device according to claim 3, wherein said edge detection means is adapted to count the number of edges, in each of said blocks, by counting the number of inversions of said binary digitized luminance signal in the vertical and horizontal directions.

5. A device according to claim 4, wherein said edge detection means is adapted to detect the edge in said image signal by second-order differentiation of said image signal, thereby detecting the number of edges in each of said blocks.

6. A device according to any preceding claim, further comprising an image memory for storing the image signal, corresponding to an image frame, generated by said image pickup means;

wherein said compensating means is adapted, in the read-out of image information from said image memory, to vary the read-out position from said image memory, in such a direction as to cancel the movement vector of the entire image frame released from said operation means.

FIG. 1

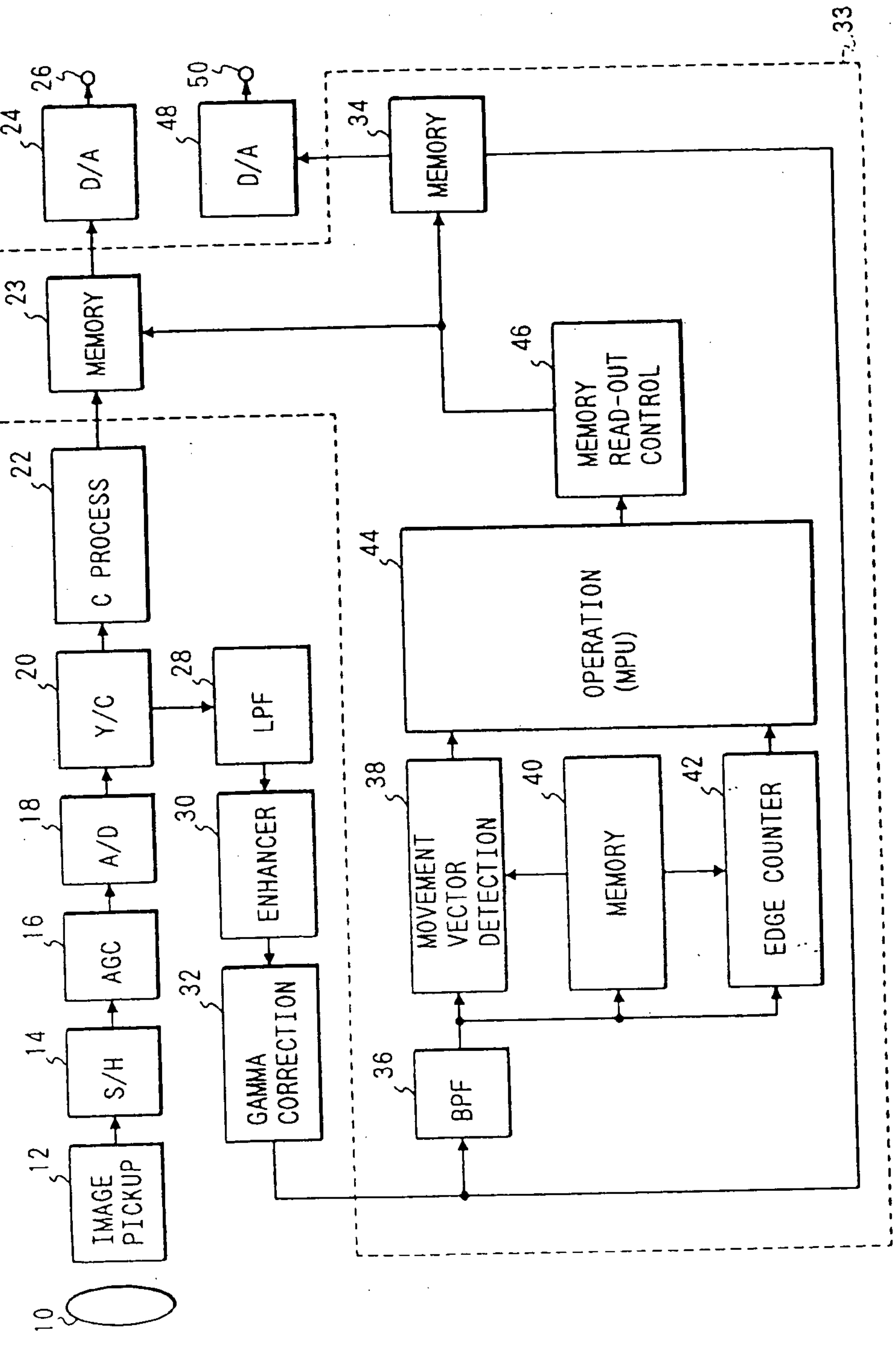
10
IMAGE PICKUP
12
S/H
14
AGC
16
A/D
18
Y/C
20
C PROCESS
22
MEMORY
23
D/A
24
26
LPF
28
ENHANCER
30
GAMMA CORRECTION
32
33
MEMORY
34
D/A
48
50
BPF
36
MOVEMENT VECTOR DETECTION
38
MEMORY
40
EDGE COUNTER
42
OPERATION (MPU)
44
MEMORY READ-OUT CONTROL
46

FIG. 2

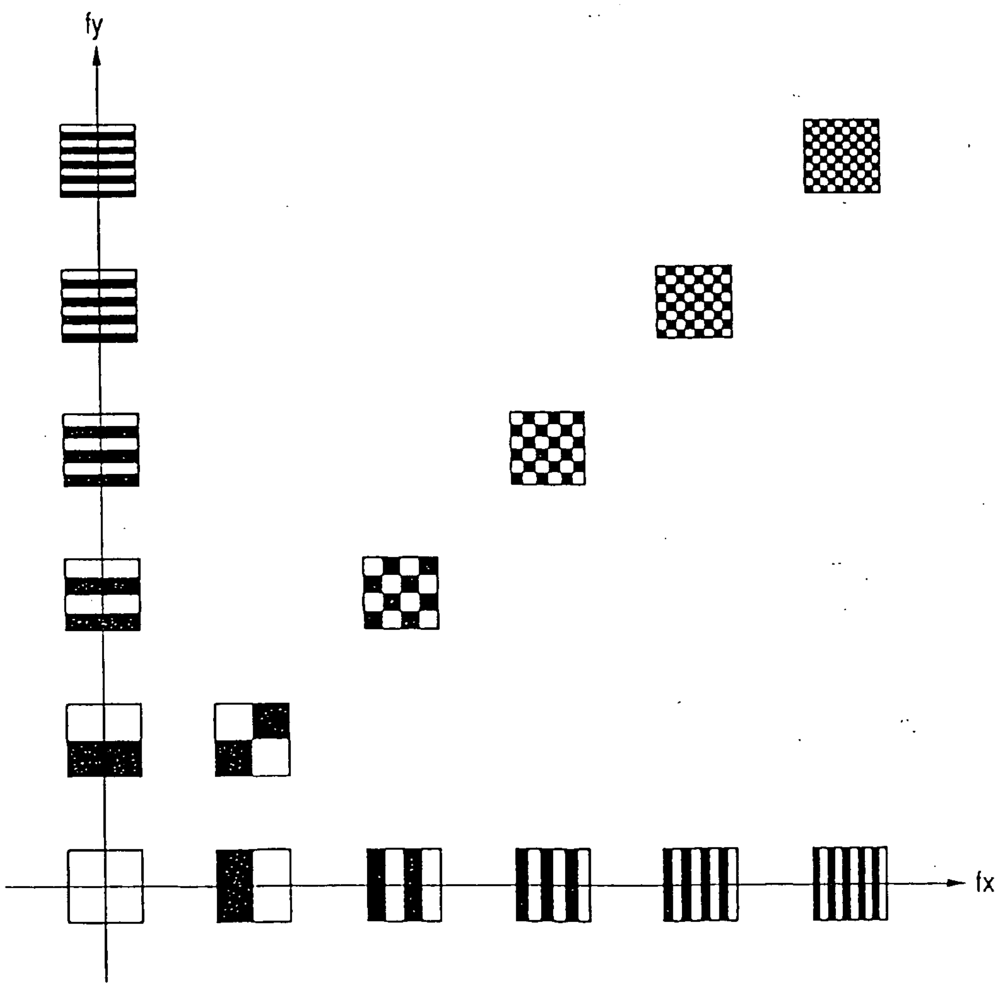

FIG. 3A

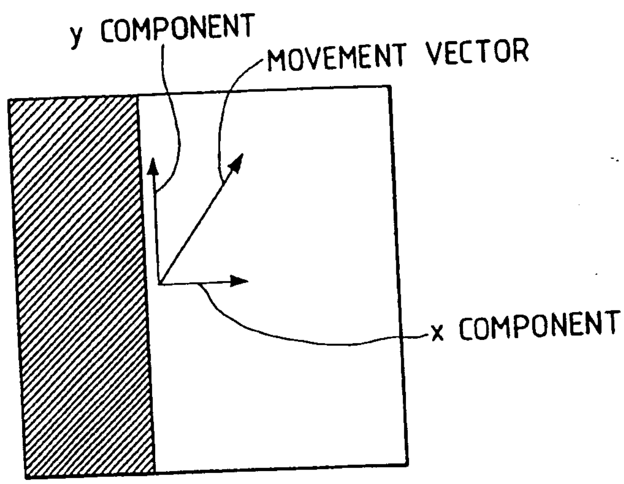

FIG. 3B

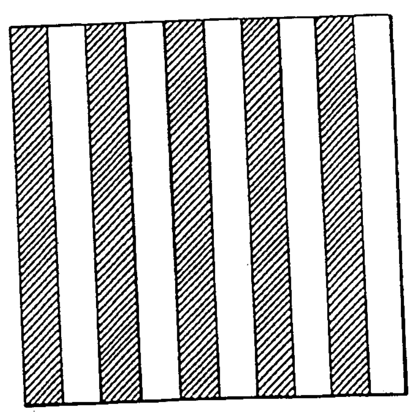

FIG. 4

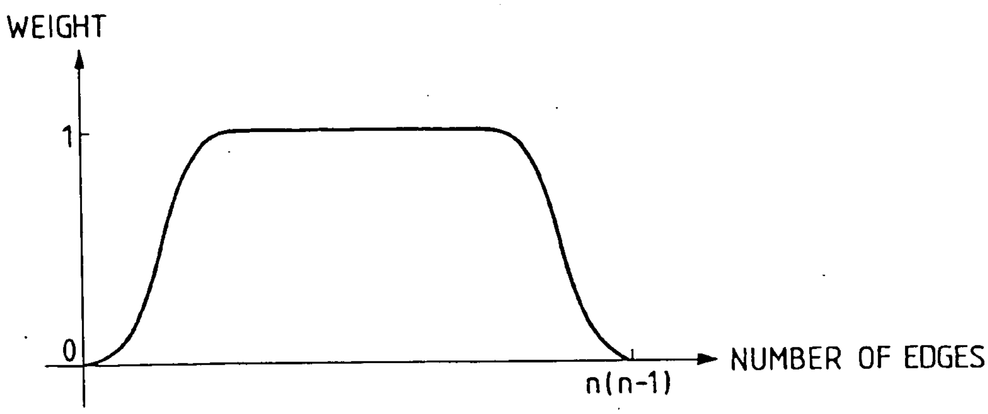

FIG. 5A

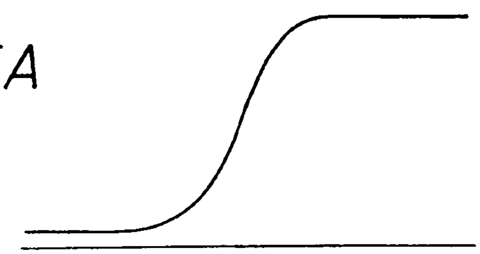

FIG. 5B

FIG. 5C

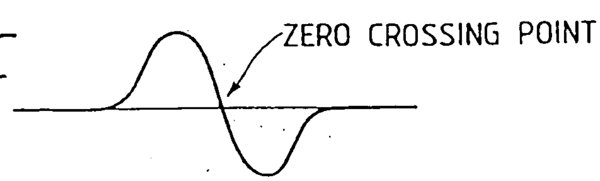

FIG. 6

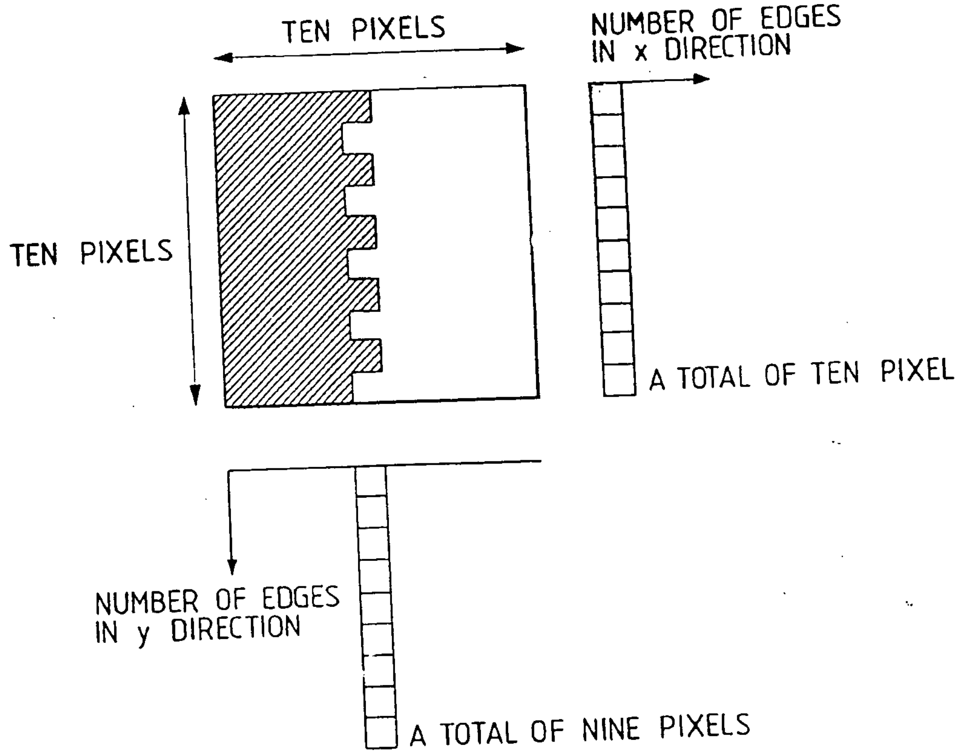
TEN PIXELS
NUMBER OF EDGES IN x DIRECTION
TEN PIXELS
A TOTAL OF TEN PIXEL
NUMBER OF EDGES IN y DIRECTION
A TOTAL OF NINE PIXELS

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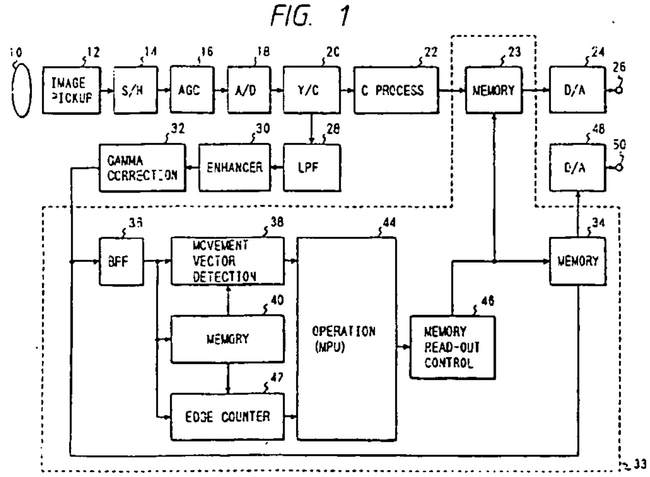
FIG. 1



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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 20 3154

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	IEEE TRANSACTIONS ON CONSUMER ELECTRONICS, vol. 37, no. 3, August 1991 NEW YORK US, pages 521-529, JOON KI PAIK ET AL 'an edge detection approach to digital image stabilization based on tri-state adaptive linear neurons' * the whole document * -----	1	H04N5/14 H04N5/232

TECHNICAL FIELDS SEARCHED (Int.Cl.5)
H04N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 February 1996	Yvonnet, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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